



A Simple Michelson Interferometer could constitute the optical subsystem of a profilometer, provided that the adjustable mirror were scanned and the output of the photodetector processed as described in the text.

for white light sources and would eliminate the need for most of the optical components of current white-light profilometers. Furthermore, whereas the height scanning ranges of current surface-measuring profilometers are of the order of millimeters, the adaptive-signal-processing method would make it possible to attain scanning ranges of the order of decimeters in the proposed profilometers.

The figure depicts the optical layout of a simple Michelson interferometer configured for use as a profilometer, according to the proposal, for measuring the deviation from flatness of a nominally flat surface that contains a pit. The pit can be

characterized as comprising multiple facets at different depth, each producing a coherence function having signal intensity proportional to its size. As a result, the output of the photodetector in this interferometer would include a multitude of overlapping coherence functions that cannot be easily discriminated.

A complete overlapping-coherence-function profile of the surface area within the interrogating light beam would be collected by recording and processing the photodetector output as a function of height while scanning the adjustable mirror through the interrogation depth. The adjustable mirror could be

mounted on a piezoelectric actuator for rapid scanning in height. Optionally, a digitally controlled micromirror device could also be used to scan the light beam laterally (horizontally in the figure) across the surface. Modern digital signal-processing hardware would be used to rapidly acquire and process the photodetector output and the overlapping coherence signals contained therein according to the adaptive method described below.

In this method, a Fourier transform of a synthetic intensity-versus-depth signal generated from a mathematical model of the surface to be measured would be subtracted from the Fourier transform of the intensity-versus-depth signal obtained by the interferometer scan of the surface to be measured. The result of the subtraction would be an error signal. The coefficients of the model, representing the sizes and depths of facets in the pit, would be adjusted to minimize the error signal. To obtain the coherence function needed for the model, it would be necessary to perform a calibration measurement, prior to operation, in which a reference mirror known to be optically smooth and flat would be substituted for the surface to be measured.

This work was done by Gregory A. Hall, Robert Youngquist, and Wasfy Mikhael of Kennedy Space Center. Further information is contained in a TSP (see page 1). KSC-12647

Improved Photon-Emission-Microscope System

An advanced photon-emission microscope is combined with the latest image-processing software.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved photon-emission-microscope (PEM) instrumentation system has been developed for use in diagnosing failure conditions in semiconductor devices, including complex integrated circuits. This system is designed primarily to image areas that emit photons, at wavelengths from 400 to 1,100 nm, associated with device failures caused by leakage of electric current through SiO₂ and other dielectric materials used in multilayer semiconductor structures. In addition, the system is sensitive enough to image areas that emit photons during normal operation. This system supplants a prior PEM system based on a photon-intensified, gated, charge-coupled-device (CCD) camera.

This system includes an optical microscope fitted with a low-light-level imaging subsystem based on a state-of-the-

art high-resolution (1,024 × 1,024 pixel), cooled, back-illumination CCD camera in a light-proof enclosure. Another major subsystem is a computer running the latest in Windows-based image-processing software, which can facilitate generation of test reports and research papers by putting out image files in popular formats, including tagged image file (TIF), bit map (BMP), and Joint Photographic Experts Group (JPG) formats.

A device under test (DUT) is placed on a translation stage under the microscope. This stage enables movement of the DUT along both axes perpendicular to the optical axis, as well as along the optical axis for focusing. Any of several microscope objective lenses affording different magnifications (5×, 20×, 50×, and 100× with

extra long working distance) can be selected. The exposure time is programmable between 5 milliseconds and 2 hours. Provisions for setups of external equipment, including the power supply for the DUT and digital multimeters, can be incorporated into custom software.

In operation, the system integrates the photons emitted from the DUT, and the resulting bright spots (showing the locations of substantial emission of photons) are displayed superimposed on an image of the DUT that was acquired previously under visible light. Failure-analysis engineers can use the information in this display to locate failure sites on the DUT.

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